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INTRODUCTION

The complexity of the marketing process and the losses which frequently result from making poor decisions have caused marketing scholars and practitioners to constantly search for better ways to predict the outcomes of alternative strategies. The typical marketing manager has little direct contact and virtually no control over those whose actions ultimately determine the success or failure of his strategies. Changing competitive conditions and consumer circumstances; interactive effects of advertising, product quality, price and distribution; and time delays in response make it difficult to evaluate, much less predict the effects of a specific program.

In spite of these difficulties significant progress has been made recently in developing new methods of analyzing complex interactive systems and decision processes such as those found in marketing. In particular, the development of simulation techniques which utilize the amazing computational power and data handling capacity of large scale computers has greatly increased researchers' ability to

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handle complex problems through the use of formal, symbolic models.

The purpose of this paper is to assess the current use and future potential of computer simulation in marketing. In the first part of the paper we will discuss the nature of the technique, some of the advantages and limitations associated with its use, and review selected studies which indicate how it has been applied to marketing problems. In the second part we will discuss the steps involved in developing and testing a complex simulation and describe the structure of a microanalytic model of buyer behavior which was designed to aid management in the generation and evaluation of alternative strategies.

CHARACTERISTICS AND APPLICATIONS OF COMPUTER SIMULATION

Although the term "simulation" has been used to describe many kinds of applications of abstract models to real situations, most operations researchers limit the meaning to:

1. the use of models which represent the essential elements of a real system or operation; and

2. the use of observations of the model's output or behavior under different experimental conditions to test hypotheses or make predictions about the real phenomenon.[1]

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[1]For example see [5] and [10].

In computer simulation the model consists of mathematical and/or logical statements and the computer is used to calculate specific outcomes when different data inputs, parameter values, or structural relations are specified.

ADVANTAGES

The approach given above stands in sharp contrast to the classical use of symbolic models where general analytical solutions are used to deduce a model's properties. Since analytical solutions are not required in performing simulations, simple models are not essential for reasons of tractability. If necessary, hundreds of mathematical and logical statements and thousands of variables can be used to build a realistic model of a complex system. Freedom from the "solution constraint" allows the researcher to let his judgment about the importance of a variable be the primary determinant of whether or not it should be included in the model. It has also stimulated the development of new kinds of models which can be used in a wide variety of problem situations. Some of these models will be described later in this paper.

Morgenthaler (10) points out that simulation can be used to overcome other difficulties encountered in applying the scientific method of investigation. Once a simulation model has been found to be a reasonable representation of the phenomenon under study, observations of the behavior of the model can be used to derive and/or test

new theories and hypotheses. This use of a model is particularly important when it is difficult or impossible to induce experimental changes and observe responses in the real environment. The idea of "artificial experimentation" with a model to deduce the effects of possible changes in real-world structure is not unique to simulation. Indeed, such deductions are the ultimate goals of most model building efforts. The advantage of simulation is that it allows these experiments to be conducted in a more complex, and usually more realistic, "artificial environment" than would be possible using purely analytical methods.

However, it should be pointed out that the ability to handle large scale models through simulation does not imply that complexity is desirable for its own sake. The principle of parsimony has not been repealed by the advent of the computer. In many cases the power of the simulation method can best be exploited by creating complex systems made up of relatively simple components. Where this is possible one can combine the advantages of parsimonious representation of microstructures with the ability to handle highly complex macrostructures. The term "micro-analytic simulation" is used to describe this approach to model building.[2]

The characteristics pointed out above make simulation a valuable marketing tool. There is little difference between using a

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[2]For an excellent example of this approach see [11].

simulation as an experimental device for evaluating theoretical models and using it to derive the implications of alternative marketing strategies. Thus, artificial experimentation through simulation can be used to produce direct inputs to management decision making.

More specifically, the major advantages of using simulation in marketing can be summed up as follows:

1. The simulation process can be used to explore the implications of management's perceptions about the external environment. Executives, salesmen, agency personnel, researchers, and other members of the firm's marketing team can pool their intuitive resources and readily available market data in order to come up with a series of statements about the behavior of consumers, middlemen, and competitors and the effect of specific marketing actions. Researchers can translate these statements into mathematical and/or logical analogues, and put them together in the form of a simulation. If the process is done well, the output of the simulation has some claim representing the implications of the perceptual inputs that went into the model. Aberrant results may be traced to errors in the interpretation of manager's statements or, more significantly, to errors or inconsistencies in the original formulations themselves.

2. Simulations can be used to integrate and systematize large quantities of information obtained from past marketing research studies and secondary sources. A model helps to place formerly isolated pieces of data in perspective and often increases the net amount of information that can be obtained from them.

3. A simulation model which has been accepted as a reasonable representation of the real world can be used to guide future research activities. Given confidence in the over-all structure of the simulation, the researcher can perform sensitivity analyses with respect to specific parameters or component characteristics. In addition to gaining general knowledge about the system's performance characteristics, these tests help to indicate what kinds of additional empirical or theoretical research will have the greatest impact upon the overall accuracy of the model. Research can then be concentrated in areas where potential results are known to be important.

4. Once a market simulation model has been validated to the satisfaction of both research and management personnel the method of artificial experimentation can be used to derive forecasts of sales levels, market penetration rates, profits, or other criterion variables conditional

upon alternative specifications of the elements of the firm's marketing mix. The model can act as a kind of synthetic test market and can be used to screen alternative strategies without incurring the risk or expense of experimentation in the real world. While some experimentation in the real world may always be desirable to settle crucial policy questions and maintain a continuous check on the validity of the simulation, the ability to screen a larger number of test candidates through artificial experimentation is likely to produce both substantial savings and better candidates for experimentation in the real environment.

The payoffs outlined in paragraphs (1) through (4) above can be viewed as forming a kind of pyramid. One may start with a purely intuitive model, supplement it with data from existing sources and use the model to generate additional research leads which can in turn be fed back to improve the accuracy of the simulation. The apex of the pyramid is attained when both intuitive confidence in the model and formal validity checks on its performance are sufficiently positive to warrant its use as a tool for helping to solve "on-line" marketing decision problems.

Another possible application of the simulation model is in the area of managerial education. Military officers have participated in war games for many years. Modern war games simulate the outcomes

of strategic and tactical decisions by means of highly complex computer models. In the business game, executives or students who are responsible for managing companies in a simulated environment have the opportunity to obtain highly realistic experience in decision making and analysis. If the simulation model represents the marketing environment of a particular company or industry with reasonable accuracy -- that is, if it meets the validation criteria implied in connection with (3) and (4) above -- the training experience can be specialized to the point where executives from the firm or industry can take away specific knowledge about market characteristics that will be immediately useful in solving day to day problems.

Finally, the effort required to build and test a simulation model usually yields an important by-product in the form of the learning experience it affords managers and researchers involved in the study. A great deal of interaction is required between managers who have the intuitive grasp of the marketing process and researchers who have the technical skill to create the simulation. This is particularly true if the model is designed to be used as a direct aid to decision making. The manager is forced to be specific about his assumptions as to how the market operates -- more specific than he is used to being in his normal day-to-day activities. Moreover, he is asked to contribute to the resolution of "ify" questions about how various outputs of the model will be used in decision making.

On the other side, the researcher must always be alert to

questions of managerial relevance and is often required to compromise in matters of technical formulation and elegance. While the task of assimulating unfamiliar concepts and communicating in an unfamiliar vernacular can lead to friction between manager and researcher, experience has shown that open minded and intelligent attempts to resolve these problems will pay off. The effort devoted to specifying assumptions in precise terms (the computer is totally unforgiving of ambiguity), carefully considering and integrating all available data, and identifying important variables and interactions to be included in the model, invariably leads to new insights about the firm's marketing environment and policies even before simulation runs are ever performed.

PROBLEMS

While there are many advantages and payoffs associated with the use of a complex simulation there are also important problems and limitations.

First of all, computer simulation is inherently expensive. Skilled model builders, computer specialists and substantial amounts of computer time are required to develop, test, and maintain a large scale system. Even relatively simple models can involve major expenditures if special studies are required to generate data for parameter estimation and model validation. While the cost of a project is obviously related to its scope, some idea of the level of expenditure

often involved is indicated by a recent survey of simulations of social, political, and economic systems. Of 41 projects for which financial information was available, 20 were reported to have cost between $10,000 and $100,000 and 17 over $100,000. Some projects involved expenditures of as much as $2,500,000. [1]

The creation and use of complex simulation systems also involves significant technical problems. Foremost among these is the question of system design for efficient computation. Although nearly anyone with elementary knowledge of computer programming can translate individual elements of a model into computer language, considerable skill is required to design a large scale simulation. The basic problems involve program overlay and file manipulation. Simulation programs of the kind emphasized in this paper are frequently too large to fit into the core memory of a computer. Under these conditions it is necessary to divide the program into segments and bring each segment into core as needed to process information. Similarly, most simulations must bring large quantities of data into core, process it, and return it to external files. While many computers can perform calculations at the rate of a million or more per second, the operations required to transfer programs and data between internal and external memory take place at a much slower rate. Hence, it is essential to minimize such activity. Seemingly trivial differences in the organization of data files and the order in which computations are performed can make the difference between an efficient simulation system and one that is economically impractical to operate.

Care must also be taken in the design of systems which will permit experimentation with different data inputs and parameter values. In some cases special input editor routines which identify different classes of control information and check for syntactical and logical inconsistencies may be required to reduce the effort involved in introducing these changes and lessen the chances of executing a costly simulation run containing input errors.

Output systems must also be designed carefully. The following general considerations are relevant. First, output from sectors of the model, and sometimes even individual functions, must be available for performance testing. Secondly, procedures must be developed for translating results obtained from simulation runs into measures which can be validated against real world data and/or used by management in decision making. Finally, efficient assimulation of information requires adequately labeled and conveniently formatted output -- the latter often involves consideration of graphical as well as numerical modes of display. The development of effective output procedures is usually a non-trivial part of the design of the total simulation system.

Formidable problems are also present in the testing phase. Most simulation models, even those of moderate size, contain so many parameters that it is impossible to do sensitivity analyses on all possible combinations of values. Hence, the researcher must use judgment or a formal technique such as random sampling to select specific

values to be included in sensitivity tests -- and hope that feasible, but untested, values will not cause the model to behave in an erratic fashion.

Ascertaining the validity of a simulation model is also a complicated task. The researcher must decide which aspects of the real system are to be used as evaluative criteria and how close the model output must be before it can be said to be valid. Although the purpose the model was designed to serve provides guide-lines for selecting variables to be compared, there is no simple way to determine when correspondence between model output and real world data warrants the conclusion that the model is a valid representation of the underlying process.

Finally, it is important to re-emphasize the limitations inherent in the use of any model. Regardless of complexity and amount of detail, a model is by definition an abstract of reality. If important variables are omitted, and inaccurate assumptions and data are used, a model cannot be expected to produce highly accurate output. This fact seems to be easily forgotten, especially when the output is nicely formatted and consists of precise numbers calculated by a computer.

MARKETING APPLICATIONS

The diagram of a marketing system shown in Figure 1 provides us with a convenient way to categorize applications of computer simula-

tion in marketing. Each block in the diagram represents a population of individual behavioral units whose decisions control the flow of product, information, and money throughout the system. Although it is possible to simulate marketing systems using detailed models of the decision processes of individual consumers, middlemen and manufacturers, few attempts to do so have been made. Most marketing simulations have focused on specific kinds of decisions or variables and have treated other aspects of the total system at a high level of aggregation or ignored them entirely.

For example, simulation has been applied to the study of physical distribution systems by Shycon and Maffie [12] and Kuehn and Hamburger [9]. In the Shycon and Maffie study a model describing the location of factories and customers, and the transportation costs from feasible warehouse locations was created. Since the model also included functions describing inventory carrying costs and warehouse operation costs at various volume levels, it could be used to calculate the total distribution cost of servicing the firm's customers with a specific warehouse configuration. By specifying different warehouse locations the costs of alternative distribution strategies could be evaluated.

The Kuehn and Hamburger study was also designed to evaluate the economic implications of alternative warehouse locations. However, this simulation does more than evaluate the cost of a given system. It also selects the locations to be tried in the model from a feasible

set which has been specified by the user. Although the heuristics employed to select locations do not guarantee that the optimal set will be found, they do insure that each location added and retained in the solution results in lowered costs for the total system. Both of these simulations ignore marketing factors other than physical distribution and treat the patterns of demand by consumers as given.

One important aspect of information flow -- exposure of consumers to formal advertising media -- has been simulated by the Simulmatics Corporation [13]. The Media-Mix model was developed to estimate the reach and pattern of exposures of alternative media schedules. Census statistics for specific market areas were used to create artificial populations of consumers with representative distributions of important demographic variables. Data from audience and readership studies were used to develop equations which would yield the probability of a particular type of consumer being exposed to a given media vehicle at a given point in time. The model gives each of the 2,944 simulated consumers an opportunity to be exposed to each insertion in a media schedule which has been specified by the user. The stochastic outcomes are recorded and tabulated in reports which show, by consumer type, the reach and frequency of exposure resulting from the insertion schedule. Since the content and format of advertisements are not considered the model does not provide information about the impact of the messages on consumer orientations.

Simulation has also been used to study decision processes of

marketing executives and consumers. For example, Howard and Morgenroth simulated the way one executive in a large manufacturing firm set prices on the firm's products [7]. After extensive interviewing of the executive, a model was created which described the way in which information from several sources was used to determine a specific price. Validation tests were conducted by selecting at random thirty-one pricing decisions made by the original executive and 130 decisions made by executives who were not studied. In each of the 161 cases the model predicted the price accurately.

Similar studies have been made of retail ordering and pricing decisions. March, Cyert and Moore created models of the decision processes employed by executives in one department of a large department store [6]. The performance of the model in predicting markups, markdowns, and sale prices was particularly impressive -- 188 of 197 markups, 140 of 159 markdowns, and 56 of 58 sales prices were predicted to the penny.

Simulations such as the above are of immense value in understanding and improving the way with which specific decisions are made. Moreover they have indicated that it may be possible to let the computer make many of the repetitive decisions which take large amounts of executive time.

Although it is known that at least one company had a detailed simulation model of consumer decision processes and buyer behavior, there are few published studies in this area. As far as we

know, the model of doctor prescribing behavior to be discussed later in this paper is the most detailed simulation of this nature to be constructed to date.

A recent article by Kotler demonstrates the use of simulation in the study of interactions between major elements of the marketing system [8]. Models describing market and competitive responses were created and used to analyze the results of new product introduction strategies for two hypothetical companies. Thirteen different strategies were postulated for each of the duopolists. Tests were run on each of the 78 strategy combinations and comparisons were made of profits and market share over a five year period. Kotler used these results to draw generalizations about the market position, rate of return and amount of risk associated with different classes of strategies. While the model is generalized, i.e., it does not represent identifiable companies and products, it is easy to see how similar models of a specific nature can be developed.

The Balderston and Hoggatt simulation of the lumber industry is one of the few attempts to use microanalytic simulation to study interactions between manufacturers, wholesalers, and retailers [4]. While the primary purpose of the project was to study market structure and the way it is affected by different message costs and various methods of determining the parties to a transaction, the authors indicate that with relatively minor modifications the model could be adapted

to permit evaluation of alternative marketing strategies. Experiments performed on the model made it possible to draw generalizations about the dynamics of market segmentation and the effect of the experimental variables on profitability and concentration at each of the levels of distribution. In addition to being an excellent example of micro-analytic simulation the documentation provided in Simulation of Market Processes makes this book a must for anyone interested in the technique.

The Total Market Environment Simulation (TOMES) is, we believe, one of the most detailed simulations of a total marketing system now in operation.[3] This simulation currently being used as a marketing game, contains artificial populations of consumers, retailers, distributors, and salesmen. In the consumer model one thousand individual decision-making units are simulated in each of nine census regions of the United States. Each consumer is described by socio-economic characteristics, probabilities of being exposed to specific media; awarenesses of brand names; and attitudes towards retailers, product characteristics, appeals, and specific brands of product. Awarenesses and attitudes about brands of product are formed by selectively perceiving the communication content of advertisements in print media, television, point of sale displays, and word-of-mouth messages generated by other simulated consumers. Individual consumers make explicit decisions to

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[3] The Total Market Environment Simulation was developed by A. E Amstutz, H. J. Claycamp, C. R. Sprague, and J. D. C. Little. It is currently being used in marketing courses at M.I.T. and Stanford University. For a more detailed discussion of the use of the model see [3].

shop, purchase, and generate word-of-mouth messages as a result of interactions between socio-economic variables and perceived brand images of specific products.

Individual retailers and wholesalers form profit expectations on the basis of communications received from manufacturers and observed consumer demand. If they decide to stock a specific brand they forecast their own sales, determine order quantities, and set their own prices.

Participants managing competing companies in this simulated environment can employ amazingly realistic marketing strategies. It is possible to vary product characteristics of a specific brand, place individual advertisements in specific regional or national media, employ individual salesmen and allocate their efforts to specific kinds of retailers, use direct or indirect distribution, etc.

Realistic research can also be done to provide information for decision making and evaluation of strategies. For example, simulated commercial services provide audits of retail sales and inventories and readership studies of specific advertisements. In addition, consumer research can be done by purchasing surveys of random samples of individual consumers in any of the nine regions.

While this simulation system was designed to teach marketing planning and decision making, it can be used as a research environment for evaluating alternative strategies and developing new analytical techniques. It also serves to illustrate the kind of richness which

can be embodied in a microanalytic simulation and the variety of uses which such a model can serve.

DEVELOPING AND TESTING COMPLEX SIMULATION SYSTEMS: AN EXAMPLE

The remainder of this paper is devoted to a discussion of the process of developing and testing complex simulation systems.[4] The procedure outlined here has been followed in developing models of markets for food products, appliances, services, securities, and electronic sub-systems, in addition to the prescription drug market example discussed in this paper.[5]

GENERAL STEPS IN THE PROCESS

Micro-analytic simulations designed for marketing management use focus on the processes through which management attempts to influence behavior in the external environment. The steps followed in creating, testing, and implementing a market oriented behavioral simulation may be summarized as follows:

1. A conceptual framework encompassing relevant attributes of the problem environment is delineated.

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[4] The work described in this paper was done in part at the Computation Center of the Massachusetts Institute of Technology and Project MAC.

[5] A discussion of system elements common to these various applications is also given in [2].

2. Elements of the environment considered important by management are established as the focus of a systematic study of market activity.

3. A theoretical structure encompasing relevant elements and processes is defined.

4. Relationships between elements and processes are expressed in quantitative and measurable terms.

5. Observed or assumed relationships are summarized in systems of equations compatible with a computer simulation structure.

6. Individual functions, system sub-segments, and the total simulation are related to data obtained from the "real world" environment.

7. Criteria of validation and performance measurement are established and model precision and accuracy are determined.

The first step in this process is to develop a broadbrush description of important factors in the marketing environment. This qualitative description serves as the basis for a non-mathematical but orderly structure which can be used to define key elements and processes.

The second step involves the design of gross macro flow models encompassing previously defined elements and processes. These preliminary descriptions of market activity define major interaction patterns and, as such, serve as cornerstones of models providing more complete and detailed descriptions of actions within relevant sub-sectors of the marketing system.

The third, fourth, and fifth steps encompass quantification of relevant behavior and development of detailed sector models. The models produced at this stage must provide sufficient scope and

refinement so that a representation of the total relevant environment may be synthesized in a single computerized simulation.

The final steps in this process involve practical implementation. The performance of the simulation must be validated against data obtained from the actual environment in which management is operating.

In the final analysis, the objective of simulation development is to produce a usable model -- a model on which operations can be performed in lieu of operation in the actual physical environment.

THE PROBLEM ENVIRONMENT

The system discussed in this paper was designed to provide the management of an international drug company with a new aid in the analysis, evaluation, and planning of marketing activities.[6] The specific objective of the project was the design of a complete simulation of the prescription drug market which would enable management to investigate in a synthetic environment the implications of alternative strategies and policies without making the commitment of resources required for comparable investigation in the real world.

In developing specifications for the system, management directed that it should facilitate: (1) evaluation of promotional (media) effectiveness; (2) evaluation of salesmen (detail men) effectiveness; (3) testing of alternative policies and strategies for

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[6] Work on this simulation was started by the authors in 1963. Some aspects of the total system are still in development.

marketing particular products to given market segment; (4) evaluation of the probable success of new products at an early stage of market development; (5) assessment of the validity of management's understanding of the dynamics of the prescription drug marketing system.

While the constraints of this paper do not permit a complete exposition of the methodology or results of this activity, highlights of the development procedure and system performance are discussed in the following pages.

SYSTEM DEVELOPMENT IN DETAIL

In developing a simulation of competitive market behavior the firm and its competitors are viewed as input generators. The external market simulation is then designed to duplicate the response characteristics of comparable real world markets to the inputs generated by the competing firms.

Boundary Definitions

System development activity normally begins with a definition of the boundary conditions which limit the scope of the system to be developed. In most instances this preliminary specification is relatively crude. Management generally attempts to describe a limited number of sectors. The description may be of the form illustrated in Figure 2. This figure shows management's preliminary conception of the prescription drug market environment. Lines connecting various

sectors of the illustration indicate management interest in interactions between these market elements.

At the outset, management must also specify the objectives which they hope to achieve through use of the system once it has been developed, validated, and implemented. Objectives of the type defined above frequently determine whether a particular aspect of the environment will be included or excluded. Proposed applications also determine the level of detail and accuracy which management requires of the operating system.

Once the desired scope and objectives have been specified, macro descriptions of behavior within the environment to be simulated can be undertaken.

Macro Specification Development

Macro specification is designed to achieve two interrelated objectives. First, it initiates the process of quantitative model formulation. Second, it provides an opportunity for managers and researchers to establish the conceptual framework and preliminary definitions of key variables.

During the macro specification phase, major emphasis is placed on stating that which management knows, assumes, and hopes. Underlying assumptions about the nature of the environment are given close scrutiny. Boundary conditions established in preliminary discussions are refined to the point where the scope and detail of future analysis and evaluation may be established. Thus, macro specifications

formalize the preliminary model structure and establish the frame of reference for all subsequent model development.

Figure 3 illustrates this step in the process of system specification. Concepts illustrated in Figure 2 have been expanded through recognition of additional sectors and more complete definition of interactions between sectors. Flows of information, orders, prescriptions, and product have been identified.

Beginning with the company in the upper left hand corner of the flow chart, product flow is followed through wholesalers, chain outlets, pharmacies, and hospitals. Parallel order flows are noted from the wholesaler, hospital, and pharmacy levels. Distribution facilitating information generated by the company is indicated as an important input to salesmen, wholesalers, pharmacies, and doctors. Information inputs to the company include observer reports, salesman reports, panel research, and direct mail research.

Salesmen are represented as receiving information from the company and transmitting it to wholesalers, pharmacies, hospitals, and doctors.

Wholesalers are perceived as receiving information directly from the company and through its salesmen, transmitting orders to the company, and receiving product from it. The small oval to the left of the wholesaler sector indicates product inventory at the wholesaler level. Inputs to the wholesaler are indicated as originating in the hospital, pharmacy, and salesman sectors. Wholesaler salesmen are represented as order takers.

Pharmacies receive information from the company via its salesmen and some wholesaler salesmen. The possibility of both direct and through-salesman order procedures is noted. Inventory maintenance is indicated by the oval to the left of the pharmacy sector.

At the level of detail represented in the Figure 3 flow chart, the hospital is analogous to a pharmacy.

The doctor is described as receiving information from the company salesmen, media, and direct mail promotion. An additional source of information is represented by the information line leaving the lower right hand corner of the doctor rectangle and returning to that same sector. This line represents doctor interaction and the generation of "word-of-mouth" communication. The company receives information inputs about the doctor sector through observer reports, panel, and direct mail research.

The patient is shown as interacting with the doctor, receiving prescriptions under control of the doctor, and under certain circumstances, initiating refill procedures.

While competitors are not illustrated in this flow chart, the actions of relevant companies are considered in detail in the actual simulation.

The process of macro specification is frequently iterative. Initial specifications provide the basis for preliminary definitions which are then modified in the light of additional conceptual development, market studies, and data constraints. For example, once preliminary formulations for the drug market simulation had been developed,

substantial time was spent in discussing these formulations with members of management as well as practicing physicians. These interactions, as well as additional analysis, and empirical research led to refinement of the initial structures.

Data Requirements

Macro specifications refine boundary conditions to the point where specific data requirements may be established. Figure 4 summarizes representative data requirements associated with the drug market simulation. The two sections of this figure distinguish between data required for model structuring and initialization and that used as input during operating runs.

Data sources included monthly audits of drug store invoices, weekly audits of prescriptions written, audits of the distribution and content of journal advertising, quarterly reports from panels of doctors who recorded individual patient treatment, direct mail promotions, and salesman details (sales messages for specific drugs). Specialized research studies were also employed to determine doctor knowledge, experience, attitudes, and treatment procedures.[7]

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[7]Generation of the data required for a simulation of this magnitude is in many cases a monumental task. However, the pahrmaceutical industry is unusually rich in commercial data services, and the company sponsoring this simulation has an especially effective market research department. Hence, much of the data required for this simulation was already in existence and only needed to be integrated into the model.

Micro Specification Development

Once key decision and response elements have been identified the focus of model development shifts to micro specification. The first activity in this phase is the creation of detailed models based on management hypotheses regarding the problem environment and verified where possible by reference to behavioral theory and existing data. Working within the structure supplied by the macro specifications each decision point is described in terms of inputs to and outputs from that decision. Hypothesized relationships between inputs and observable behavior are formulated in terms of measurements which permit validation of the model against data from the real world. Each functional relationship is explicitly described in mathematical or logical expressions, and instructions for computer system design and programming are established.

Simulations of the type being considered here involve unusually complex computer programs. As a result, a major portion of micro specification normally focuses on the creation and testing of computer programs required for data packing, multi-level system control, and overlapped processing.

Description of a Decision Process

The conceptual framework summarized in the macro specification hypothesizes a doctor's decision to prescribe particular drugs for a patient exhibiting specified indications (illnesses). Treatment may take place in the doctor's office, a hospital, or the patient's

home. In any case, the fundamental problem facing the physician is selection of the appropriate therapy on the basis of his present knowledge, attitudes and experience.

Basic characteristics of the simulated drug selection procedure are summarized in the Figure 5 flow chart. This representation begins with the initialization of a doctor decision matrix, DRDECM. All elements of this matrix are initialized at zero. Thus, in the beginning the process the doctor is assumed to have no predisposition other than that reflected in his memory of associations and experience.

The indication(s) exhibited by the patient are noted by the doctor who recalls one or more drugs which might be used in treatment. This process is simulated by placing a 1 in the drug decision matrix position representing each drug which has been associated with treatment of the exhibited indication(s). If, upon completion of this process, the matrix is zero, the association process has failed and the doctor adopts a more complex procedure.

The second procedure involves a systematic evaluation of the doctor's past experience with relevant drugs. In the simulation, this process is initiated by setting appropriate drug matrix positions to 1 indicating that all drugs in the set are equally appropriate for consideration. The doctor deletes from consideration those drugs toward which he has a negative attitude as a result of previous experience. (Drugs previously used in treating each patient are recorded in the patient's treatment record to facilitate identification.) At this point in the decision process if the doctor is in a hospital all drugs

not included in the hospital formulary are deleted from consideration.

If the matrix is zero following this process, reconsideration is effected using modified standards as specified at location 10 in the flow chart. If the matrix contains one or more non-zero entries, the doctor's attitude toward each remaining drug is established. All drugs for which the resulting attitude is negative are then removed from consideration. If there are no drugs toward which the doctor has a positive orientation, no drug is used. If, on the other hand, one or more positive attitude drugs remain, the process continues to the entry specified as position 20 in the flow chart.

At position 20 the doctor considers each remaining drug in terms of his past success in achieving desired therapy in similar circumstances. Historically unsatisfactory drugs are rejected with the corresponding entries in the drug matrix set to zero. If, following this procedure, all drugs are eliminated, drugs deleted due to unsatisfactory historical performance may be reconsidered with a less stringent performance requirement.

If several drugs remain to be considered after either the initial or revised test, the doctor makes a choice based on his attitude toward each drug remaining under consideration. If his attitude toward all drugs is equivalent he will have an equal probability of choosing any one of the drugs. If, on the other hand, his attitude toward one drug is more favorable, his choice is biased in favor of that drug.

Additional Function Formulation

In a similar manner, each decision and response function encompassed by macro specifications is investigated. In some instances initial theoretical constructs are validated. In others, empirical evidence suggesting alternative constructs is obtained and the process of formulation is repeated for revised structures.

The final structure established by micro specifications includes processes through which the doctor is exposed and responds to media, conventions, salesmen, and word-of-mouth communication; evaluates indications exhibited by a patient; establishes desired actions, efficacy, and safety; and schedules the patient for a return visit.

Explicit Decision Representation

Decision and response functions are formulated and tested as probabilities since data from the real world environment are in the form of frequency distributions. Generation of explicit decision outputs for each cell within a simulated population requires conversion of the probabilistic statement into explicit yes/no decisions. A number drawn randomly from a rectangular distribution of range 0 to 1.0 is compared with the stated probability to determine each probabilistic event.

AN EXAMPLE OF THE SIMULATION PROCESS

Behavior within each sector of the simulated environment must be described in terms of interrelated decision and response functions of the type illustrated above. In addition to describing

functional relationships, the system designer must develop a representation of the dynamic processes which produce behavior observed within and between sectors of the market.

The operation of a micro-analytic simulation can be most easily described by discussing the basic flow of information through the system and examining characteristics of the processes through which behavior is created. The basic structure of the prescription drug market simulation is illustrated in Figure 6.

System Initialization

On entry, the system prints certain title and control information on output tapes (A-3) and the on-line printer. Tables developed by a pre-processor program are then read into core storage to establish information to be referenced during the simulation cycle and initialize operating parameters.

Doctor File Input

Each simulated doctor is described by the content of a doctor file record. Doctor files are recorded on tape sequentially by geographic region. A single doctor file is held in core at a given point in time. After simulating the doctor's activity for a specified number of weeks the file is updated to reflect his experiences, and written on tape. A new doctor is then read into core, and the procedure is repeated.

The Time Loop

As indicated above, the system is structured so that time is moved past each doctor in turn. This organization of the system is necessitated by the large size of the doctor file record which makes it impractical to move doctors in and out of core or to maintain more than one doctor in core at a given point in time.

During most simulation runs, the time period considered is one simulated year. The time step is one week and the time index (IT) proceeds sequentially from 1 through 52. Events occurring during a particular week are identified by a monotonic date code, which, during processing of the simulation, is referenced to the time index (IT).

Doctor Response to Media Promotion

During each week in simulated time, the publication frequency of each relevant journal is tested to determine whether it is published during the week under consideration. If a particular journal appears, the probability of the doctor then under consideration being exposed to that journal is developed. If, on the basis of this probability it is determined that the doctor will be exposed to the journal, each advertisement appearing in an advertisement schedule table for that journal is examined to determine whether or not the doctor will be exposed to, and assimilate any new information. When an advertisement is assimilated the doctor's response to the message is established and his memory updated to take account of information content. This process is continued for all media, messages and doctors at each point in time.

Direct Mail Response

The handling of direct mail response is structured in a manner analogous to media promotion. During each simulated week, a comparison is made to determine whether any direct mail pieces appear. If a direct mail piece is being sent during the week in question, exposure probabilities are developed to determine whether or not the particular doctor then being considered will be exposed to the specified mailing. If exposure occurs, assimilation probabilities are generated and, if on the basis of these probabilities it is determined that the doctor will assimilate portions of the communication, his response is determined and his memory updated.

Response to Salesman Detail

In developing a representation of the doctor's response to salesman communication, the probability of exposure is first determined on the basis of parameter values in the doctor file record which establish the probability that the doctor will receive a call from a salesman representing any one of the relevant companies. If the doctor is exposed to a salesman from a particular company the schedule of details (sales messages for a specific drug) presented by that salesman is examined to determine which details are being presented to doctors of the indicated specialty during the week under consideration. If a particular detail is presented and assimilation occurs, the doctor memory is updated. As in the case of all other communication response loops, this procedure continues until all sales messages have been considered.

Response to Convention Activity

Exposure to presentations at a convention is based on a convention schedule which specifies the probability of a doctor of a particular specialty and residence attending a convention held at a particular time. In keeping with the previously established procedure, the convention schedule is examined once each simulated week to determine whether or not a convention is being held. If a convention is being held, the probability of the doctor then in core attending that convention is determined and, if the doctor is found to attend the convention, procedures similar to those outlined above are used to determine exposure to and assimilation of relevant information.

Response to Word-of-Mouth Communication

Within the structure of the simulation, messages generated by doctors in a particular region are accumulated along with descriptors of the generating doctor in a table of word-of-mouth messages. Thus, when a particular doctor is in core, messages generated at various points in time by doctors preceding him are available in the word-of-mouth table. This table is referenced in a manner analogous to the schedule and content table discussed for other media. The probability of interaction between the doctor in core and the message generating doctor who preceded him is established. If the doctor is exposed to the word-of-mouth communication the probability of assimilation is developed in a manner analogous to other communication functions and the doctor's memory is updated to reflect the word-of-mouth interaction.

Treatment of Patients

The simulated doctor is exposed to patients from an artificial patient population which is supplied as an input to the simulation. An average patient load parameter in each doctor file record determines how many patients will be treated in a given week. In treating a patient the simulated doctor determines what drug or drugs, if any, will be prescribed for the exhibited indication(s) of the patient.

Once treatment has been decided upon, the probability that it will achieve desired results is established on the basis of clinical data. If it is determined that the treatment undertaken will not prove effective within a specified period of time, the patient is maintained in a backlog of patients who will return to the doctor at some time in the future. If the outcome of treatment is successful, the patient is for all practical purposes dropped from the model. In either instance, the trial and outcome (including possible side effects) of a particular treatment is noted.

After the first simulated week the doctor has two sources of patients: (1) patients in the population from which his original patient group was drawn; and (2) patients who require continuing treatment. During subsequent time periods the doctor's first source of patients is the returning patient file. After all patients previously treated and scheduled to return have been treated the doctor considers new patients from the outside population.

Generation of Word-of-Mouth Communication

As the doctor considers various drugs in context of the treatment during the simulated week, a record of his attitude toward his experiences is maintained. Following completion of the treatment cycle for a particular simulated week, this record is examined to determine whether the doctor will generate word-of-mouth communication regarding some aspect of his recent treatment experience. If such word-of-mouth communication is generated, communication content is established, dated, and stored in the word-of-mouth communication file for later referencing by other doctors.

Forgetting

At certain prescribed time intervals, the doctor's memory is examined to determine whether forgetting would have occurred during the lapsed time period. The memory record for each drug is examined and if forgetting has occurred, the record is reduced.

Time Cycle Combination

The basic process described above is repeated for each week in the simulated year for each doctor in the artificial population. Once the final week (IT=52) for a given doctor is completed, an activity report is generated and the doctor file record is updated to reflect his experiences during the simulated year. This record is then written on tape to serve as an input for simulation of future time periods.

Following completion of a given doctor record, the simulation returns to the point in the Figure 6 flow chart labeled "A", reads another doctor record from the tape file, and repeats the process as described. After all doctors have been considered for the specified period of simulated time, a final summary report is written and the simulation terminates.

TESTING

Once a simulation has been developed to the point where it can be used to produce artificial behavior, the emphasis shifts to testing. Although the ultimate test of any model is its usefulness, the stability, reliability and validity of a simulation should be ascertained before it is used as an operational tool.

Stability Testing

Stability tests are concerned with the reasonableness of the model's performance when it is subjected to different, but feasible, parameter values and input data, and run for substantial periods of time. The major problems encountered in stability testing are selection of specific parameter values, definition of "reasonable" performance, and determination of an appropriate time period for the test.

Reliability Testing

Tests of reliability focus primarily on the question of reproducability of results. The basic problem is one of determining

stochastic variations of important outputs when different series of random numbers are used to determine specific outcomes within the system. Confidence intervals for important outputs can be established using various statistical techniques.

Validity Testing

Tests of validity are concerned with "truth." While reliability may be assessed using standard statistical techniques there are no objective measures of truth. Consequently, the researcher must turn to a subjective evaluation of the accuracy of the assumptions used to create the model and the consistency of its performance with theory and empirical data. In the final analysis, a model is realistic if it duplicates the relevant characteristics of the real phenomenon. For example, Turing has suggested that a model may be called "realistic" if a person knowledgeable in the subject being modeled -- i.e., a person having experience with the relevant reality -- cannot distinguish model output from output generated by the real system. Thus, once the validity of assumptions has been established tests must be made of model output.

The procedure normally followed in testing the validity of a micro analytic simulation is to proceed sequentially through analyses of individual functions, individual cell behavior and total population behavior.

Function Validation

Since the number of functions involved in a large scale simulation usually precludes exhaustive testing, this activity is usually limited to investigation of the performance of functions which are known to be essential to system operation.

Cell Level Validation

The objective of validation at the cell level is to establish that the behavior of an individual within the simulated population cannot be differentiated from that of a similar member of the real world population. Figures 7 and 8 illustrate the kind of output which can be obtained from the drug simulation for purposes of cell validation. Figure 7 summarizes the characteristics of a single ficticious doctor at the time when he began a particular week of simulated activity. The doctor in question is a general practitioner between 45 and 60 years of age in private practice in the midwest. He employs a nurse-receptionist and treats an average of 136 patients per week. Data following these descriptors indicate the doctor's media habits expressed in terms of circulation and exposure probabilities for major journals encompassed by the simulation. Company exposure probabilities indicate this doctor's historical frequency of interaction with salesmen from companies included in the simulated environment. The doctor's previous treatment experience is summarized at the bottom of Figure 7 in statistics showing seasonalized proportions of his practice devoted to treatment of relevant indications.

Figure 8 illustrates a simulated doctor's treatment of a geriatric patient suffering from an upper respiratory infection. The output indicates that on a prior contact with this patient the doctor prescribed two drugs. On this visit the patient's condition is improving; however, the doctor is now concerned with an anxiety reaction and undue fatigue exhibited by the patient. Noting this condition, the doctor is seeking anti-depressant and general tonic actions. The Figure 8 output provides a detailed account of the process through which the doctor elects to prescribe a new drug.

The Turing test of cell behavior was conducted by developing exhibits, such as shown in Figures 7 and 8, which describe patient treatment by actual and simulated doctors. These profiles were then examined by practicing physicians who assessed the "reasonableness" of the exhibited behavior. The results of tests involving many different kinds of therapy indicated the simulation produced highly realistic behavior at the cell level.

It is important to note that the physicians were not asked to evaluate the quality of the treatment given patients by the artificial doctors. They were to evaluate whether or not the simulated behavior was equivalent to behavior generated by similar doctors in comparable real world circumstances. Since the simulation is designed to be an accurate description of the real world environment normative questions are irrelevant.

Once the legitimacy of simulated behavior of the type outlined in Figures 7 and 8 has been established through Turing tests,

the system may be used to produce behavior over time.

Figure 9 illustrates the cumulative prescription market shares generated by two general practitioners operating in the simulated environment during one year. These two doctors prescribed only one relevant drug during the first two weeks of simulated activity. However, as the year progressed, they tried six other drugs. Their cumulative brand shares for the ten brands are shown at week 52. Output of the type illustrated in Figure 9 is used primarily to test system stability.

Population Level Validation

Meaningful tests of population behavior require aggregation of simulated cell behavior. In the doctor case, population behavior is validated by analyzing the proportion of prescriptions allocated to each brand (brand shares), and changes in knowledge, attitudes, and perceived brand images of important segments of the population.

For example, Figure 10 illustrates the brand shares of ten frequently used drugs resulting from 100 simulated doctors' treatment of several thousand patients. In conducting such tests, the population is initialized to duplicate the distribution of relevant parameters as they existed at a specified point in time in the real world environment. In the case of the Figure 10 run, the artificial population was initialized to correspond to conditions existing at the beginning of 1961.

Inputs to the simulation during performance tests describe

conditions existing in the real world during the relevant time period. In this case inputs specified the content and media allocation for all journal, direct mail, salesman detail, and convention promotion generated by competitors operating in the relevant market area during 1961. Tests performed following this simulation run established that the rank order of brand shares at the end of 1961 in the real and simulated worlds were equivalent (Figure 11) and the maximum error for any one brand was less than six percentage points.

It should be pointed out that this test is a duplication of history -- not a prediction of the future. A great deal of real world data was used in providing inputs for this test and in estimating important parameters. When the model is used for prediction of the future, subjective judgment must be used to develop inputs, and assumptions must be made about the stability of important parameters.

MANAGEMENT USES OF MICRO ANALYTIC SIMULATION

Given a system of the type described in this paper, management must assess system performance in terms of intended applications. If, in their opinion, performance is sufficient to warrant use of the simulation as a representation of the real world environment, applications of the type outlined below may be appropriate. However, if, in their opinion, the simulation fails to duplicate salient attributes of the real world environment further development leading to a more refined system must be undertaken or the use of the technique rejected.

Testing Implicit Models

One of the first benefits to accrue from the development of a simulation system is the systematic testing of management conceptions of the environment in which they operate. In reviewing alternative formulations and evaluating functions, cell model behavior, and total population performance, management must make explicit the implicit models which they use in decision making.

The "What If?" Question

Given that management accepts simulation performance as indicative of real world response under comparable conditions, the simulation becomes a test market without a memory in which management may examine with impunity the implications of alternative policies and strategies. Whether introducing new products or considering modification of a marketing program, management may apply alternative strategies in the simulated environment and evaluate their implications under various assumed competitive conditions.

The effectiveness of such pretesting is dependent on management's ability to predict probable competitive responses to proposed actions, as well as the accuracy of the simulation system. Management may find it profitable to examine the impact of best and worst case competitive response patterns. In most instances the best case assumes that competition will continue with programs developed prior to initiation of company actions, while the worst case assumes full competitor

knowledge of the proposed company program and actions designed to thwart company efforts.

Performance References

The simulated environment also provides the reference points against which the progress of operations in the real world may be measured. Given a simulation pre-test, management can determine, by monitoring appropriate variables, whether or not a program is progressing as planned. If conditions producing satisfactory performance in the simulated environment are encountered in the real world, it is assumed that final results will be comparable.

SUMMARY

In this paper we have attempted to discuss the general characteristics of computer simulation, and the process of creating, testing, and using a complex simulation system. In discussing marketing applications we have emphasized complex models and micro analytic simulations since we believe that they best illustrate the differential advantages of the simulation technique.

Finally, the future of simulation in marketing appears to be particularly promising for at least two reasons. First, although systems such as the drug market simulation tax the capacity of the largest commercially available computers, new computers with larger

memories and even greater computational speed are being developed. And second, in spite of the expensive nature of computer simulation, increasing numbers of marketing scholars and executives are coming to agree with the philosophy voiced by a top executive of the firm sponsoring the drug simulation -- "Even if there are significant errors in prediction, it is worth the expense because of the way it makes people think."

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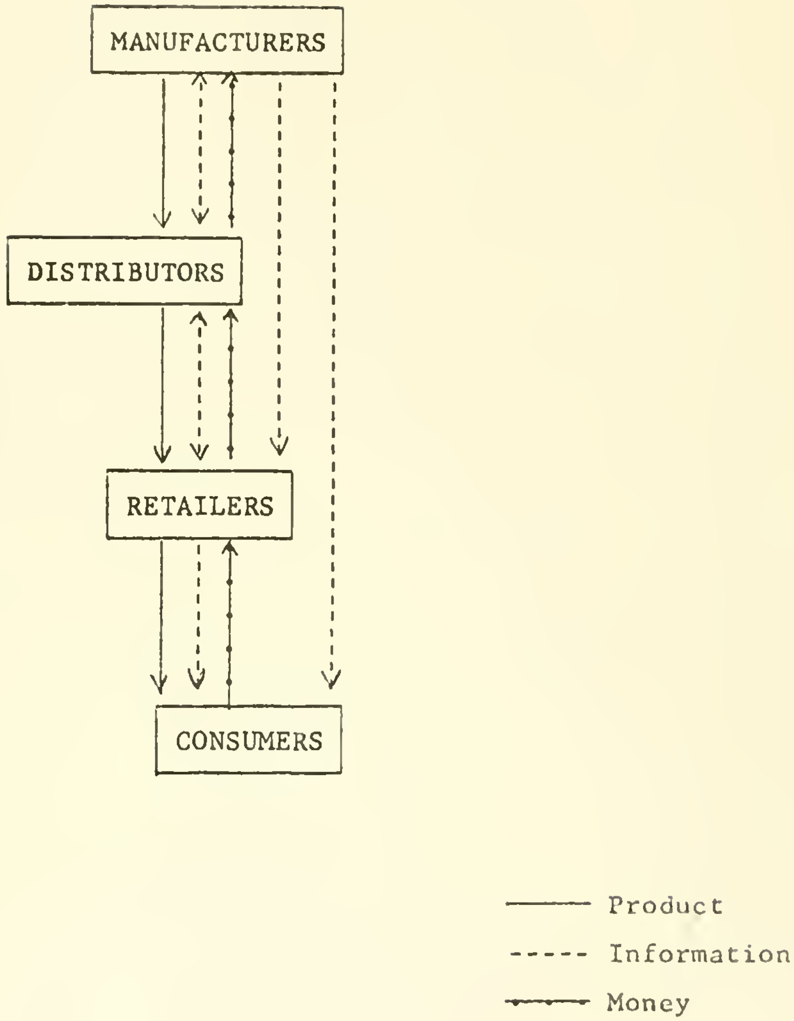
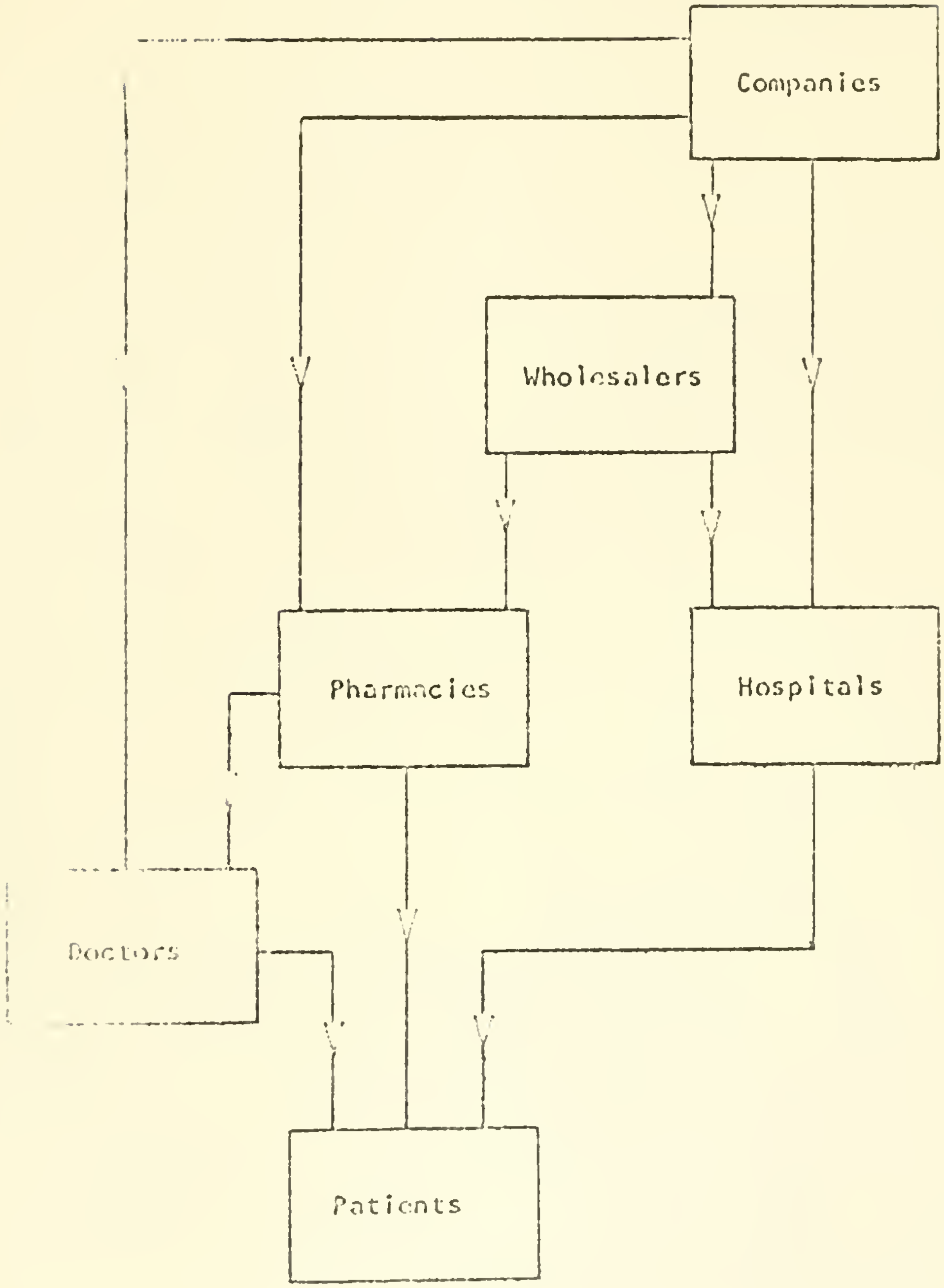


FIGURE 1

A Simplified Representation of
A Consumer Marketing System

Figure 2

BOUNDARY DEFINITIONS -- AN EXAMPLE



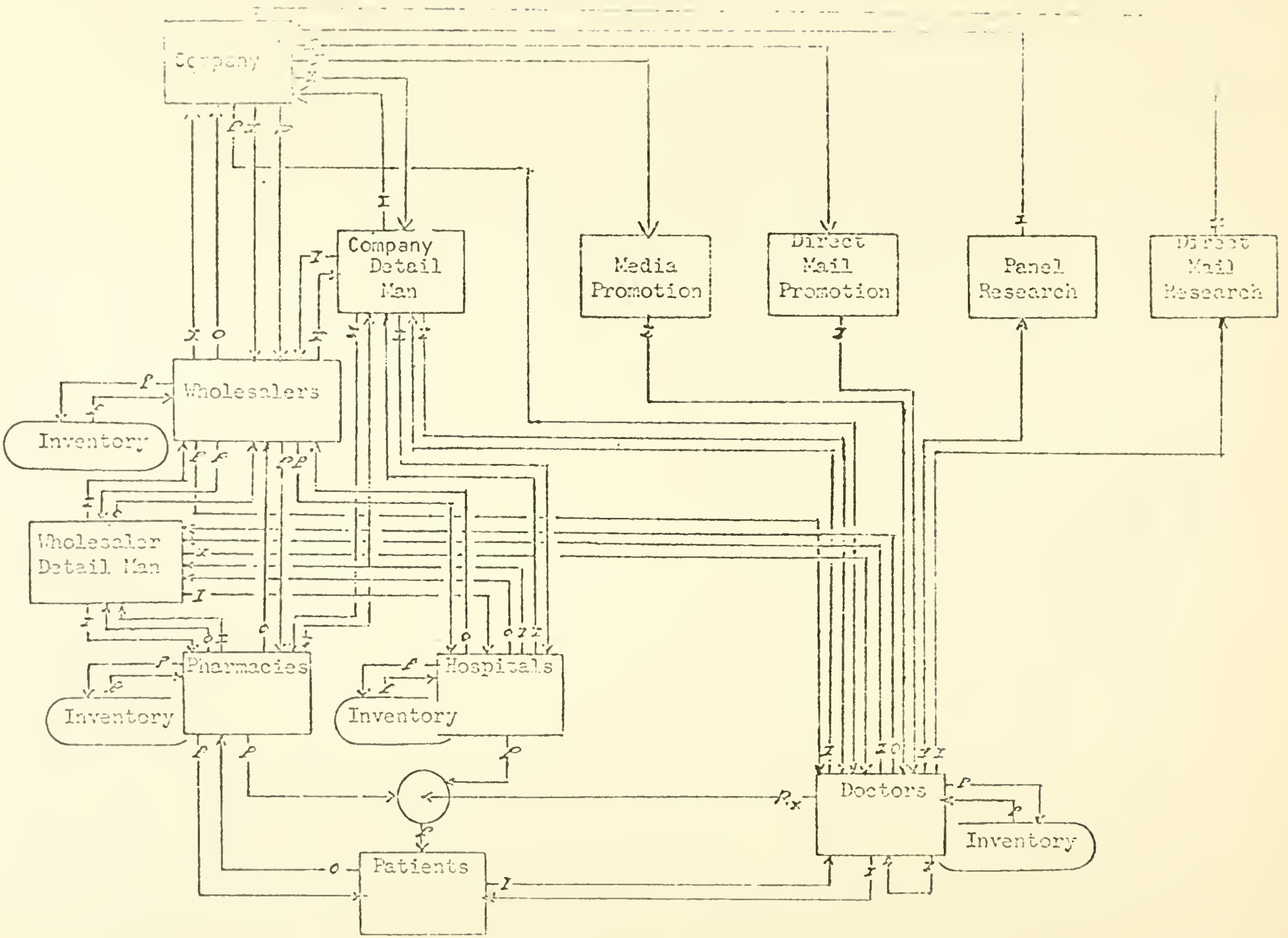


Figure 3

Macro Specifications -- An Example

FIGURE 4

Examples of Data Requirements for Initialization and Input -- Drug Simulation

1. Specification and Initialization

   A. Identification of indications

      1. Name
      2. Code number associated with name
      3. Seasonal incidence of indication

         a. By specialty
         b. By region

      4. Prioritization of indications
      5. Duration of indications

   B. Identification of drugs

      1. Name
      2. Code number associated with name
      3. Classification code
      4. Manufacturer code

   C. Initialization information for drugs

      1. Drug code number
      2. Uses of specific drugs for specific indications

         a. Number of appearances by Doctor type
         b. Success ratios in treating each indication

      3. Existing promoted brand image

         a. Print media utilization during preceding year

            1) Media identification by code number
            2) Number of full page equivalents run in each medium
            3) Content

         b. Description of direct mail promotion during preceding year -- as in 'a' above

Figure 4 (continued)

c. Description of detail program during preceding year

1) Number of product details during year
2) Number of sample calls during year
3) Content

D. Identification of distribution channels

1. Major wholesalers

a. Territories covered
b. Relevant drugs handled

2. Major drug outlets as in 1 above
3. Major hospitals as in 1 above

E. Identification of company salesman

1. Territory code
2. Average number of calls per day to doctors, hospitals, and pharmacies

F. Identification of competitive companies

1. Company name
2. Manufacturer code
3. Number of salesmen
4. Average number of calls per day to doctors, hospitals, and pharmacies

G. Indication - action - appeals matrix

1. By indication
2. By specialty

H. Number of doctors by type

1. Drug usage record
2. Media availabilities
3. Proportion of practice devoted to treatment of indications
4. Patient load, etc.

Figure 4 (continued)

II. Input

A. Variance in incidence of indication

1. By indication
2. By time period

B. Media advertising -- specified for each advertisement

1. Date of release
2. Media code
3. Drug promoted
4. Ad format
5. Ad content

    a. Appeals
    b. Actions
    c. Indications

C. Direct mail specification

1. Date of mailing
2. Region mailed
3. Proportion of each specialty mailed
4. Content - as in B-5 above

D. Company salesman detail

1. Date of release
2. Drug promoted
3. Priority
4. Content of detail - as in B-5 above

E. Company sample handling

1. Drug code
2. Sample size
3. Number of samples
4. Proportion of specialty covered
5. Territories sampled
6. Date of sampling

Figure 4 (continued)

F. Convention presentations

1. Date
2. Product presented
3. Attendance

    a. Regions from which attendance drawn
    b. Specialty from which attendance drawn

4. Content of presentation - as in B-5 above

G. Symposia

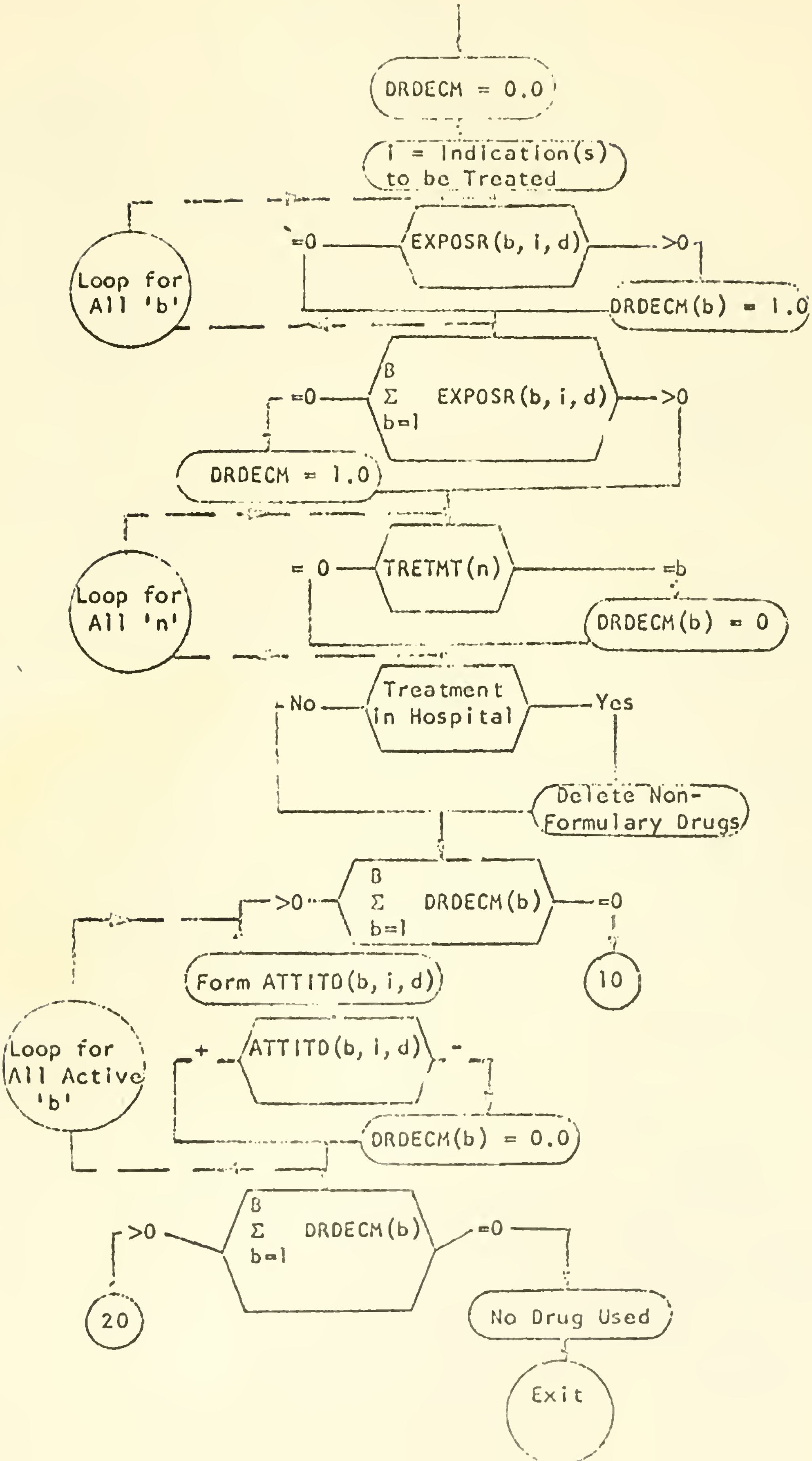
- Handled as conventions

H. Public relations releases

- Handled as advertising

Figure 5

DRUG SELECTION PROCEDURE



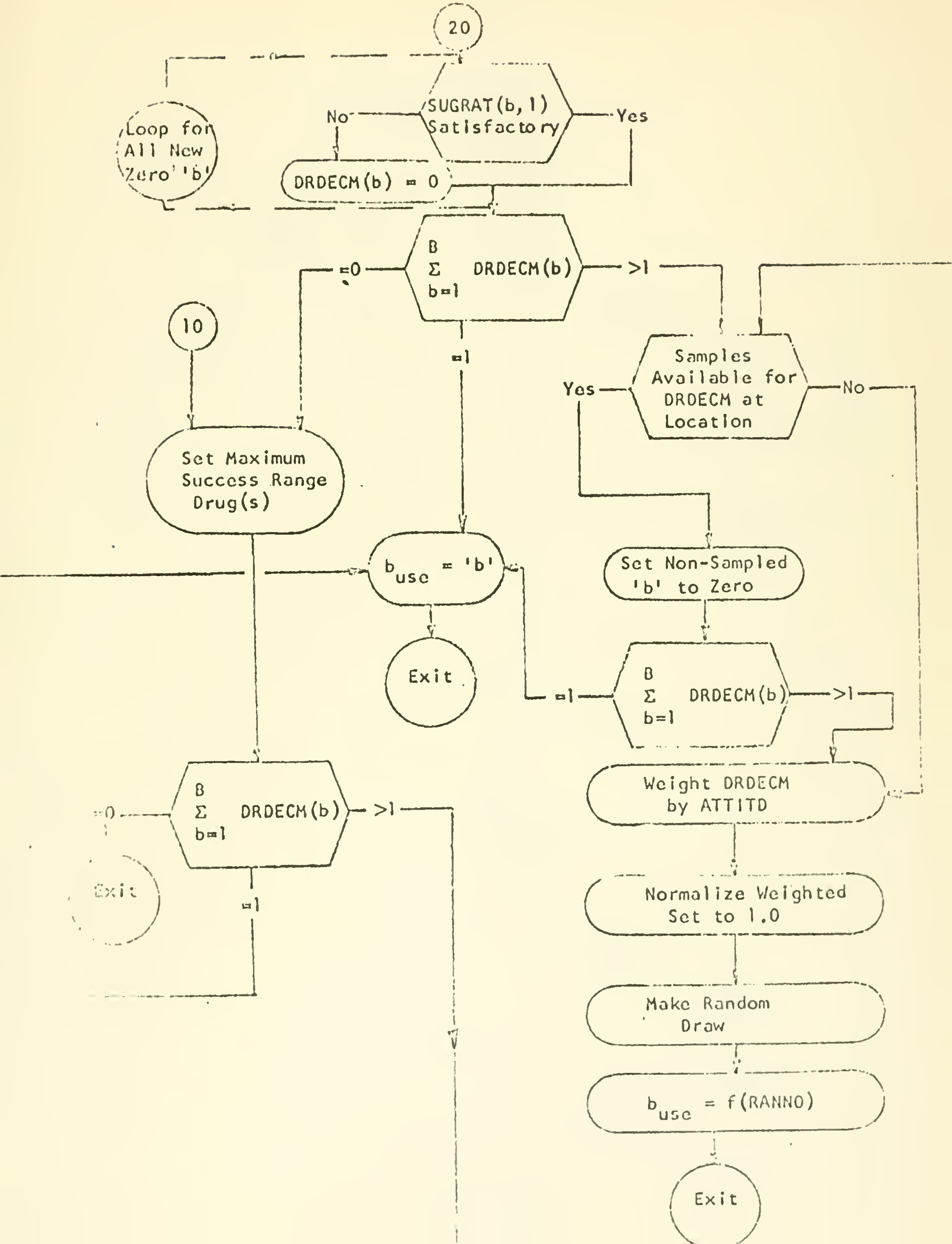

20
SUGRAT(b, 1) Satisfactory
No
Yes
Loop for All New Zero 'b'
DRDECM(b) = 0
B Σ b=1 DRDECM(b)
=0
>1
=1
10
Samples Available for DRDECM at Location
Yes
No
Set Maximum Success Range Drug(s)
b use = 'b'
Set Non-Sampled 'b' to Zero
Exit
B Σ b=1 DRDECM(b)
=1
>1
B Σ b=1 DRDECM(b)
=0
>1
Weight DRDECM by ATTITD
Exit
=1
Normalize Weighted Set to 1.0
Make Random Draw
b use = f(RANNO)
Exit

Figure 6

MACRO FLOW CHART OF SYSTEM OPERATION

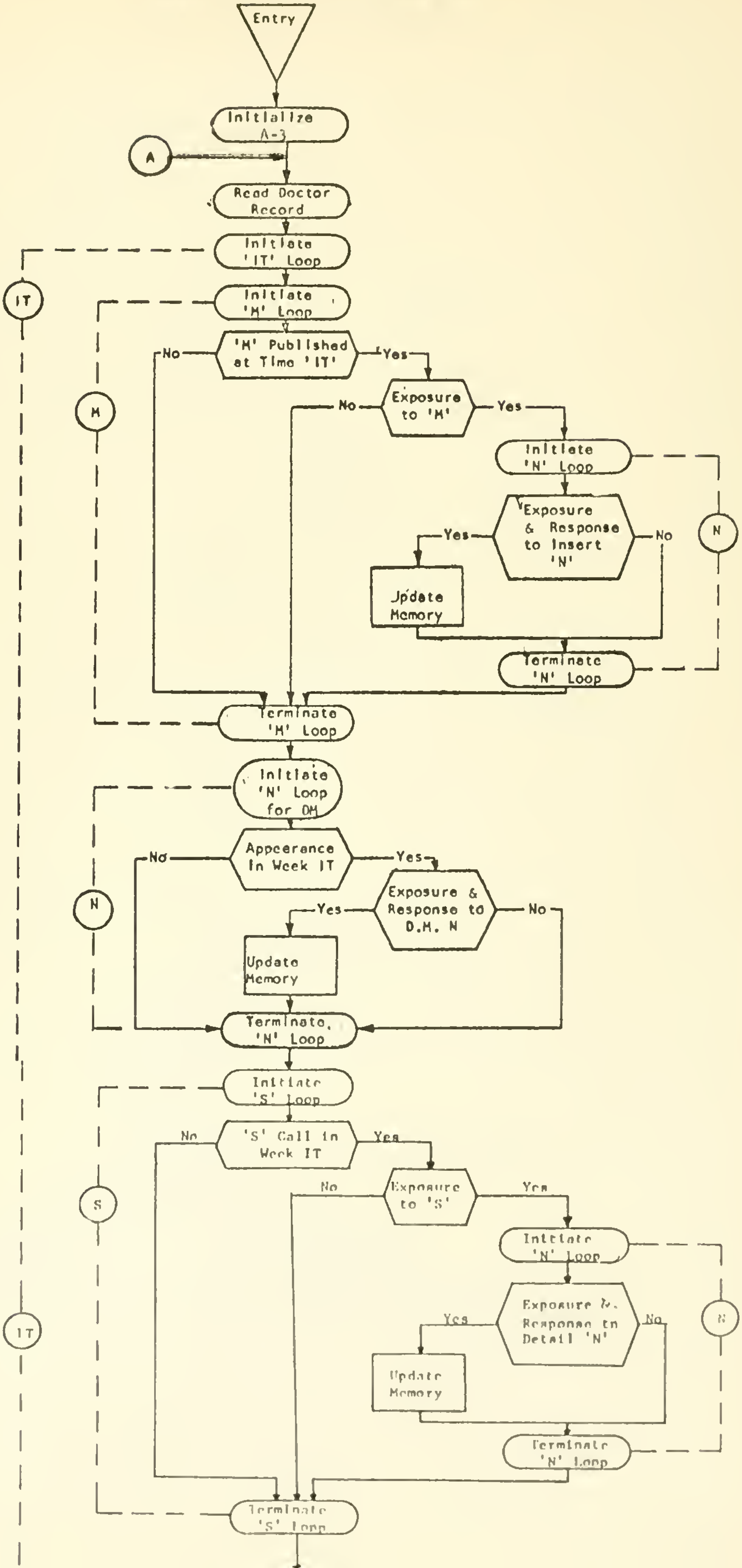


FIGURE 6 --

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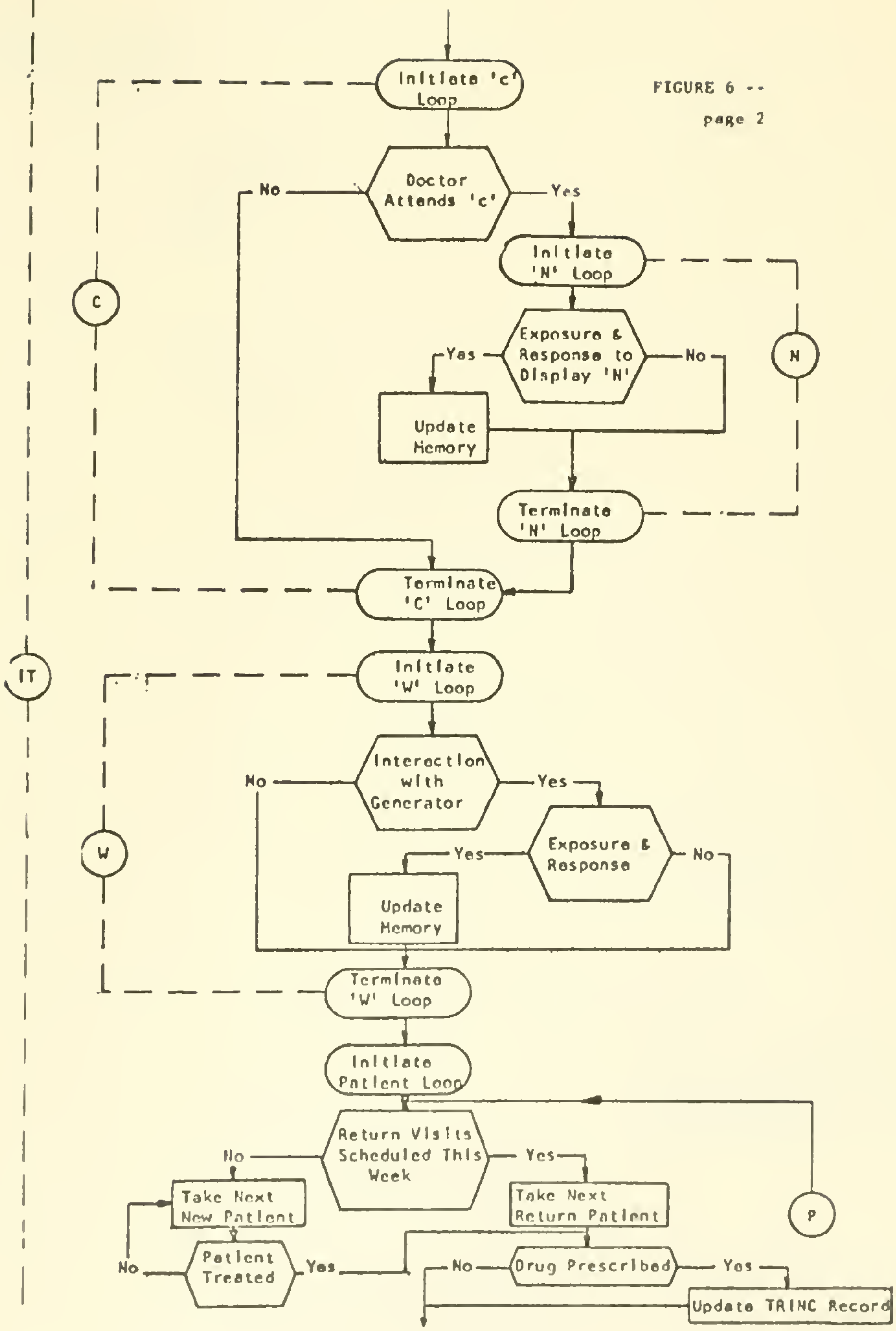


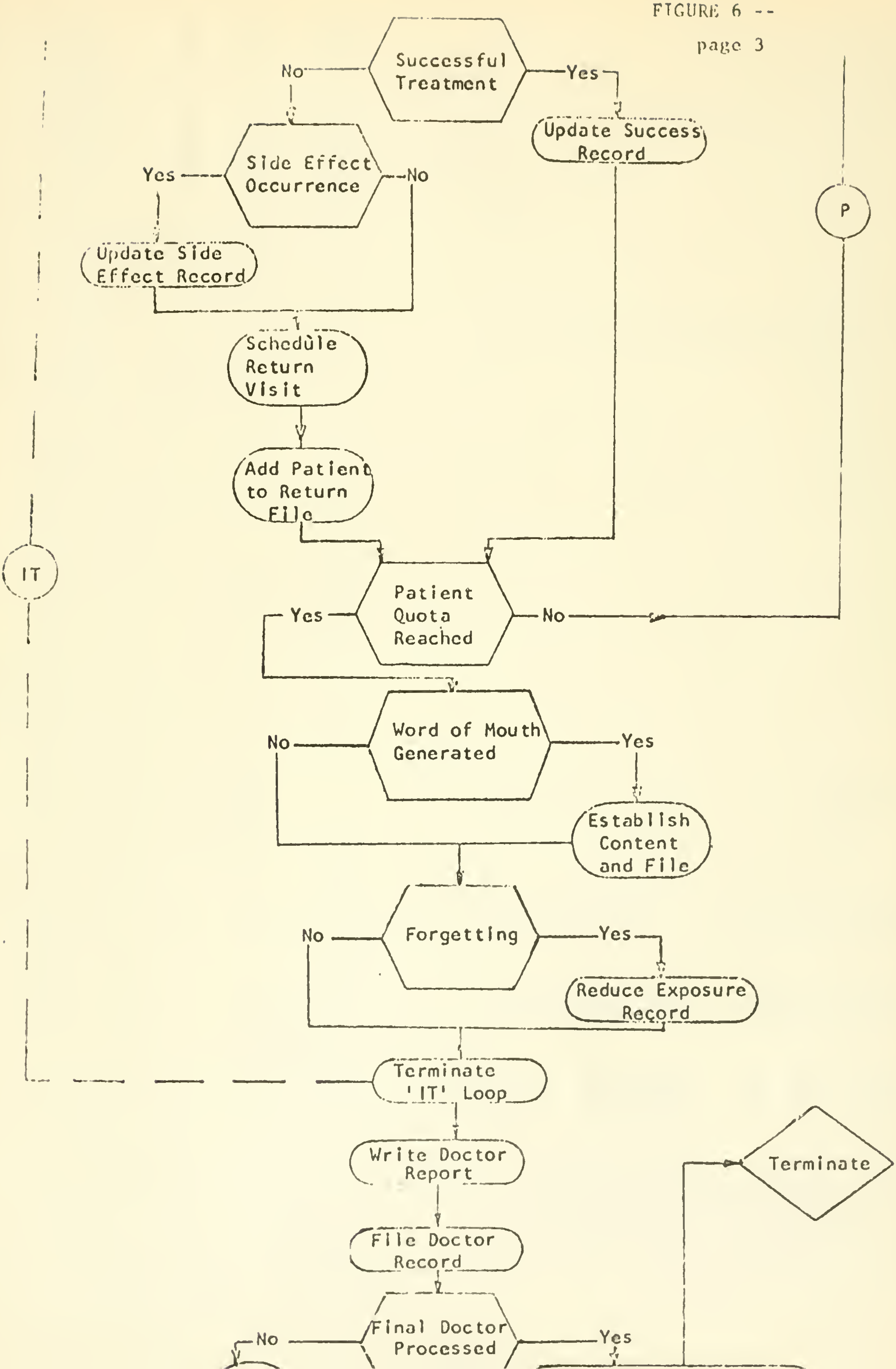

Successful Treatment
No
Yes
Side Effect Occurrence
Yes
No
Update Success Record
P
Update Side Effect Record
Schedule Return Visit
Add Patient to Return File
IT
Patient Quota Reached
Yes
No
Word of Mouth Generated
No
Yes
Establish Content and File
Forgetting
No
Yes
Reduce Exposure Record
Terminate 'IT' Loop
Write Doctor Report
Terminate
File Doctor Record
Final Doctor Processed
No
Yes

FIGURE 7

TURING TEST RE MULTIPLE DRUG USE --- MARCH 26, 1966

OR 1, OF SPECIALTY 1, S.M.A. 1 IN NDTI REGION 2, PRACTICE TYPE 1, AGE CAT. 3 IS NOW BEGINNING

AGE PATIENTS TREATED PER WEEK 136 SCREENING EMPLOYEE INDICATOR 1

ULATION PROBABILITIES

000 0.5750 0.3050 0.9480 1.0000 0.9220 1.0000 0.5030 0.0440 0.9410 0.9510 0.9080 1.0000

A-EXPOSURE-PROBABILITES

280 0.1640 0.1280 0.2670 0.3620 0.2560 0.1510 0.1410 0.1220 0.2520 0.3080 0.1130 0.1850

ANY EXPOSURE PROBABILITIES

00 0.2000 0.1400 0.1000 0. 0.2000 0.1400 0.1600 0.0200 0.4800 0.5300 0.1500 0.1300 0.1800 0.450

00 0.3700 0.3100 0.1900 0.1600 0.1300 0. 0.1800 0.3300 0.3300 0.0800 0.4700 0. 0.1400 0.170

EIGHTING 1

ONAL PROPORTION OF PRACTICE TREATING INDICATIONS OF INTEREST , DOCTOR'S PROBABILITY OF USING A SIMUL

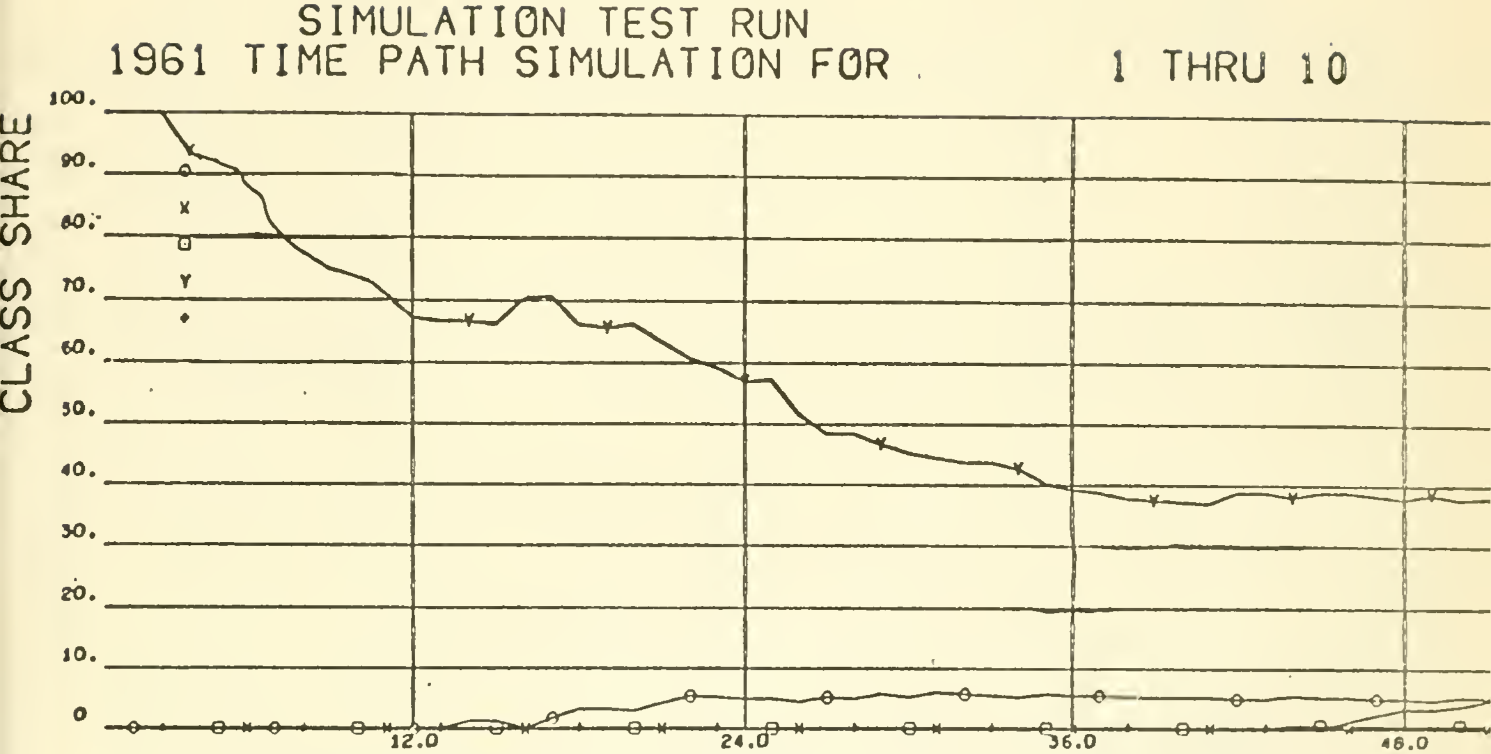
1	TB	.0009	.0007	.0012	.0010	0.
2	SYPLIS	.0004	.0000	.0004	.0009	0.0446
3	GONORR	.0009	.0011	.0010	.0014	0.
4	OT-VED	.	.0001	.0001	.0002	0.
5	INFINT	.0180	.0200	.0113	.0215	0.0197
6	SCAFVR	.0001	.0001	.0002	.	0.
7	STRPST	.0065	.0008	.0023	.0043	0.
8	CT-RAD	.0004	.0000	.	.0003	0.
9	VININF	.0002	.0000	.0003	.0002	0.
10	SPIRXS	.	.	.	.	0.
11	POLIO	.	.	.0000	.	0.
12	MESLES	.0029	.0023	.0015	.	0.
13	GERMES	.	.0002	.0004	.0004	0.
14	CHIKPX	.0009	.0010	.0005	.	0.
15	HERZOS	.0014	.0016	.0024	.0017	0.0173
16	MUMPS	.0013	.0002	.0005	.0004	0.
17	INFHEP	.0005	.0011	.0005	.0006	0.0117
18	GLANFV	.0000	.0003	.0005	.0006	0.
19	OT-VID	.0027	.0020	.0023	.0008	0.0024
20	M-T-RD	.	.	.0001	.0001	0.

```
PATIENT    1 IS A GERIATRIC,SEEN  1 TIMES PREVIOUSLY AND GIVEN APPOINTMENT IN WEEK  5
PATIENT EXHIBITS INCICATIONS URI     WITH  0 ACTIONS DESIRED ,        ,
                              CONDITION IMPROVING.
                              ANXREA WITH  2 ACTIONS DESIRED , ADEPRE, TNCGEN,
                              CONDITION UNCHANGED.
PRESENT TREATMENT DRUGS NONSIM, TOFRAN,        . NO PRIOR TREATMENT.
DRUG   1 EQUANL NOTED AS ASSOCIATED WITH INDICATION  47 ANXREA
DRUG   2 LIBRUM NOTED AS ASSOCIATED WITH INDICATION  47 ANXREA
DRUG   3 MILTWN NOTED AS ASSOCIATED WITH INDICATION  47 ANXREA
DRUG   6 MARPLN NOTED AS ASSOCIATED WITH INDICATION  47 ANXREA
DRUG   8 RITALN NOTED AS ASSOCIATED WITH INDICATION  47 ANXREA
DRUG   9 TOFRAN NOTED AS ASSOCIATED WITH INDICATION  47 ANXREA
DRUG   9 TOFRAN DELETED DUE TO PRIOR TREATMENT
DRUG  1 EQUANL ATTITUDE FORMED =        3 FOR IND. 80 URI    AND  47 ANXREA
DRUG  2 LIBRUM ATTITUDE FORMED =        2 FOR IND. 80 URI    AND  47 ANXREA
DRUG  3 MILTWN ATTITUDE FORMED =        0 FOR IND. 80 URI    AND  47 ANXREA
DRUG  6 MARPLN ATTITUDE FORMED =        2 FOR IND. 80 URI    AND  47 ANXREA
DRUG  8 RITALN ATTITUDE FORMED =        0 FOR IND. 80 URI    AND  47 ANXREA
DRUG   3 MILTWN DELETED DUE TO NEG. OR ZERO ATD.
DRUG   8 RITALN DELETED DUE TO NEG. OR ZERO ATD.


DETERMINING HIGHEST CRITERIA DRUG, IPATH = 1, ICASE = 1
DRUG  1 EQUANL, CRITERIA VALUE =  3.000
DRUG  2 LIBRUM, CRITERIA VALUE =  2.000
DRUG  6 MARPLN, CRITERIA VALUE =  2.000
 1 UNSATISFIED ACTIONS  TNCGEN
DRUG  2 LIBRUM ATTITUDE FORMED =        0 FOR UNSATISFIED ACTIONS
DRUG  3 MILTWN ATTITUDE FORMED =        0 FOR UNSATISFIED ACTIONS
DRUG  4 STELAZ ATTITUDE FORMED =        0 FOR UNSATISFIED ACTIONS
DRUG  5 THORAZ ATTITUDE FORMED =        0 FOR UNSATISFIED ACTIONS
DRUG  6 MARPLN ATTITUDE FORMED =        0 FOR UNSATISFIED ACTIONS
DRUG  7 PARNAT ATTITUDE FORMED =        0 FOR UNSATISFIED ACTIONS
DRUG  8 RITALN ATTITUDE FORMED =        0 FOR UNSATISFIED ACTIONS
DRUG 10 NOLDAR ATTITUDE FORMED =        0 FOR UNSATISFIED ACTIONS
DRUG 11 PLACDL ATTITUDE FORMED =        0 FOR UNSATISFIED ACTIONS
NO DRUG FOR UNSATISFIED ACTIONS
EVALUATION COMPLETED, TEMP SET    0  0    1  0    0  0 ID1        ID2 EQUANL ID3
FATE, RETURN  0, SUCCESS 1 1 0,  S.E. 0 0 0
```

FIGURE 9

Sample Output -- Two Doctors



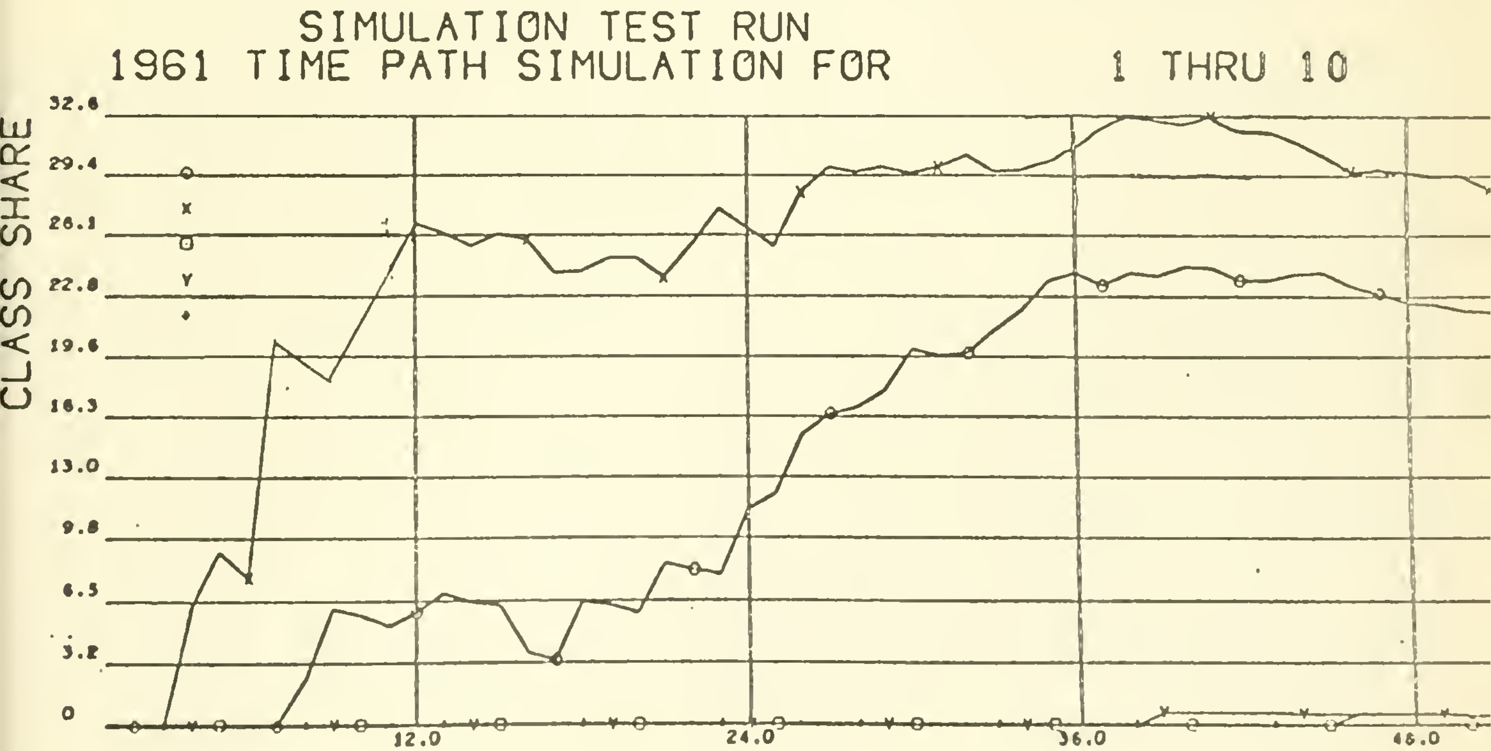


FIGURE 10

Sample Output -- 100 Doctors

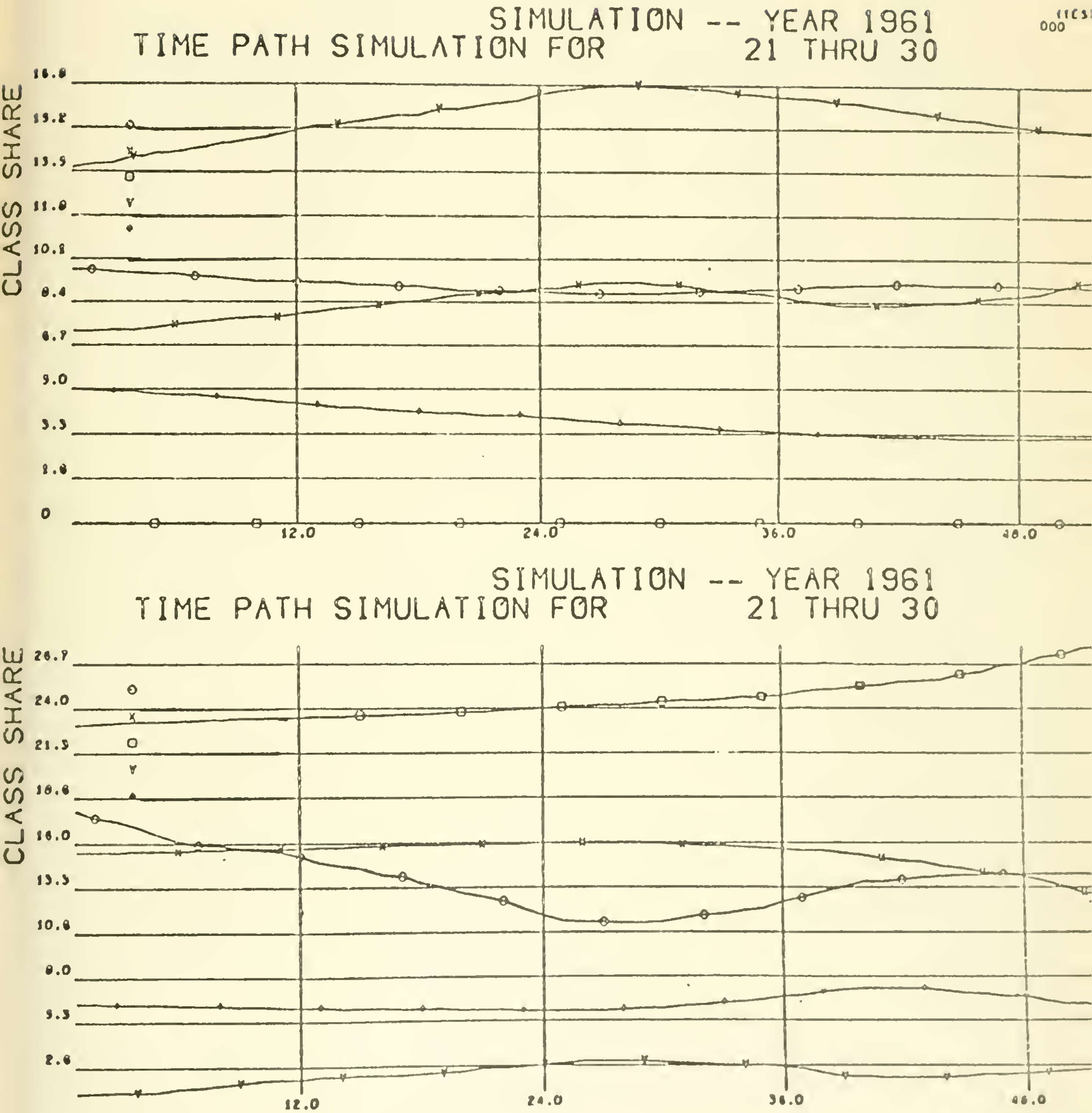


FIGURE 11

Rank Order Brand Share Comparisons

Identification	Rank as Initialized	Year End Rank Simulated	Year End Rank Actual
1 - Y	4	2	2
1 - 0	5	6	6
1 - X	6	5	5
1 - +	8	8	8
1 - □	10	10	10
2 - □	1	1	1
2 - 0	2	3	3
2 - X	3	4	4
2 - +	7	7	7
2 - Y	9	9	9